AUGUST 2018 Update

Small Cells Forecast

Major changes to the forecast this quarter include:

1. As expected, the Small Cell market is off to a good start with a robust growth in N. America, China, and Asia-Pacific regions. In addition, we observed increasing small cell activities in L. America and MEA, though those regions are starting from a smaller base.

2. We have picked up some new information on DRS (e.g., Huawei's LampSite and Ericsson's Radio Dot) hub unit pricing, decreasing pricing but increasing future volume. As a result, our current Carrier Indoor revenue figures have been reduced. Moreover, we have retroactively changed the revenue accounting for the Carrier Indoor segment for the prior years. As a result, the revised Carrier Indoor forecast is now $1.2B ($1.8B previously) in 2017 growing to $1.8B ($2.2B previously) in 2018.

3. The Carrier Indoor segment is experiencing a very robust growth especially in China as the operators continue to densify and "digitize" indoor spaces with DRS deployments in preparation for 5G. We believe these indoor LTE deployments will eventually transition to 5G. Major tier 1 vendors have all announced 5G DRS units operating in the C-band (3.5 GHz), and we expect a small number of these units to be deployed in late 2019 with mass deployments starting in 2020. We believe operators will increasingly look to small cells for network coverage and capacity extensions in indoor spaces. We have upgraded our Carrier Indoor shipment growth to 25% CAGR during our forecast period. (We had previously forecasted 21% CAGR.)

4. Meanwhile, we have downgraded our growth projections for Carrier Outdoor segment as we see operators looking to densify with "Macro" class base station units. Based on our current definition of millimeter wave/phased array small cells (i.e., EIRP below +52 dBm), most of 5G "small cells" operating in millimeter wave are actually Macro units in our forecast accounting. As the major operators in North America, China, Korea, and Japan start to make major 5G investments, we believe the investments will first and foremost start at the Macro layer, and the LTE small cell investments will be reduced as a result. While we still believe there is a robust growth opportunity in the Carrier Outdoor segment, we forecast a more moderate shipment growth of 13% during our forecast period.

5. In North America, we observe robust operator activities around small cell deployments.

    a. With the possible T-Mobile/Sprint merger in the background, Sprint continues to be very active in small cell deployments, ranging from residential femtocells, MagicBox for enterprise and select residential deployments, and Carrier Outdoor units. With strategic

partnerships with the cable operators, Altice and Cox, Sprint is quickly rolling out strand-mount small cells on fiber/coaxial strands in between poles.

b. With 600 MHz coverage overlay, T-Mobile is selectively leveraging small cells in both outdoor and indoor context to increase capacity through LAA. We believe T-Mobile and other operators will increasingly rely on LAA to provide 5G-like throughput speed increase as more LAA-capable handsets come to market.

c. Verizon continues to expand its network capacity through a combination of spectrum carrier and small cell deployments. With over 1000 markets with LTE-Advanced features like carrier aggregation, 4x4 MIMO, etc., we believe Verizon will also take advantage of LAA and additional CBRS bands to increase network capacity in select areas. With the upcoming 5G fixed wireless commercial launch in LA, Sacramento, Houston and possibly one other city in the second half of this year, we expect about 1000-2000 "5G" base stations to be deployed for this service. As noted above, these 5G millimeter wave base stations are Macro units (hence, they are not included in this Small Cells report).

d. AT&T is scheduled to launch LAA in 24 markets by the end of 2018. It has deployed LAA (in outdoor and some indoor) in 15 markets to date. The scope of these deployments in terms of unit shipments will be limited in the near term.

6. In China, the Carrier Indoor market is dominated by the Distributed Radio Systems (DRS) deployments with Huawei's Lampsite, Ericsson's Radio Dot, and ZTE's QCell. We expect the integrated small cell shipments to be limited except for some high-power outdoor units to China Mobile, Unicom and Telecom.

7. In Southeast Asia, we see broad interests across the different categories of small cells. Some operators are choosing compact, high-power Carrier Outdoor units for network coverage in remote areas. Some are choosing wireless relay small cells (e.g., AIrspan's MagicBox, Huawei's Libero) to quickly extend coverage and capacity. In India, since the initial LTE network launch, the small cell activities at Jio has tapered off. While we do see some small cell activities around residential femtocell deployments at some of Jio's peers in India, they are not at the scale of small cell deployments that we saw initially.

8. In Europe, operators are taking some interest in small cells, but this has not translated into mass deployments outside of selective residential femtocell and enterprise deployments. Based on the industry structure and "hands-on" regulatory environment, operators seem inclined to wait out the initial 5G "waves" in North America and China before making heavy investments there.

9. The CBRS market momentum continues apace in the USA. The market trials by mobile operators, cable operators, neutral host providers, and Wireless ISPs for fixed wireless continues as the SAS operation gets certified and GAA deployments start in the second half

of this year. The fixed wireless and private LTE applications are likely the leading use cases initially.

10. We are seeing a robust LAA adoption in North America, namely Verizon, T-Mobile, and AT&T. Sprint is expected to continue its network expansion via small cells and macro site expansion with its abundant treasure trove of 2.5 GHz spectrum. The early LAA results show dramatic user throughput speed increases. We believe operators in other regions will also adopt LAA in the coming years.

11. In terms of market shares in the first half of 2018, Nokia continues to lead in Carrier Outdoor and Residential segments though its pace of growth has tapered off. Huawei has increased its leading position in the Carrier Indoor segment with robust growth in China and introduction of wireless relay small cells. Ericsson continues to steadily grow its share in both Carrier Indoor and Outdoor segments. Meanwhile, Spidercloud is seeing robust growth in Enterprise category especially North America as enterprise mobile infrastructure investment continues to grow in the region.

12. Overall, the Small Cells market saw a robust growth in the first half of 2018 especially in the Carrier Indoor segment with heavy indoor deployments of DRS units. The growth in Carrier Outdoor has tapered off somewhat in the first half as operators look towards Macro investments in preparation for 5G. Meanwhile, the Residential segment continues to be a steady market with a relatively smaller market opportunity compared to Enterprise segment which is aided by new CBRS spectrum and business models.